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Value of Mesquite Leaves as Forage

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ABSTRACT

The nutritive value of six species or cultivars of mesquite (Prosopis) *was investigated: viz* P alba, P articulata, P chilensis, P nigra, P velutina *and cv 'Ruby'. Chemical analyses indicated that all of these are suitable sources of forage. However,* in vitro *digestibilities are negatively correlated with the content of phenolic compounds. Species with high concentrations of phenolics* (P alba *and* P chilensis) *are significantly less digestible than other species with lower phenolic content. Toxicity of the phenolic components of* P chilensis *leaves was observed in feeding studies with weanling mice.*

Key words: Prosopis, mesquite, forage, *P alba, P articulata, P chilensis, P nigra, P velutina,* digestibilities, phenolics, mice, leaves, toxicity, composition.

1 INTRODUCTION

Mesquite trees and shrubs, various species of *Prosopis*, are vigorous, drought- and heat-tolerant plants that are able to survive and even thrive in many arid parts of the world. In some of these regions mesquite leaves and pods are principal sources of forage during dry seasons (Skerman 1977; Felker 1979; Becker *et al* 1984). Species of mesquite that have been reported to be useful sources of forage for cattle, sheep, goats and camels include: *Prosopis juliflora* in India (Gowda and Ramaswamy 1960; Ganguli *et al* 1964), *P glandulosa* in the USA (Skerman 1977), *P specigera* D (syn *P cineraria* L) in India (Ganguli *et al* 1964; Gupta *et al* 1974), *P tamarugo* in Chile (Pak *et al* 1977), *P chilensis* in South America and India (Skerman 1977), and *P pallida* in Australia (Skerman 1977).

Detailed studies have been made of the nutritive value of mesquite seed pods for man and livestock (Latrille *et al* 1971; Becker and Grosjean 1980; Becker *et al* 1984).

Less is known about the value of mesquite leaves. This is a report of a study of the nutritive value of leaves from six species or cultivars of mesquite.

2 MATERIALS AND METHODS

2.1 Mesquite leaves

Fresh mesquite leaves were collected from trees planted by P Felker at the Imperial Valley Conservation Research Center, USDA, Brawley, California. These leaves were transported on ice for 2 days before being freeze dried. Leaves from the following *Prosopis* species were included: *alba*, *articulata*, *chilensis*, *nigra* and *velutina*, and an accession from Thermal, California: field code 'Ruby'.

2.2 Analyses

Proximate analyses were carried out by AOAC methods (AOAC 1980). Fiber and fiber component analyses were based on the procedures of Goering and Van Soest (1970). Hydrolysis for amino acid analyses was done *in vacuo* for 22 h at 110°C with 6 M HCl (Kohler and Palter 1967). A separate hydrolysis was done, after performic acid oxidation, for cystine and methionine. Phenolic compounds were determined in 80% methanol extracts of dried leaves using the Folin–Ciocalteu reagent without added cupric ion (Lowry *et al* 1951). This method is not specific for tannins but yields a measure of total phenolic compounds. Results were expressed as tannic acid equivalents.

2.3 Enzymic digestibility

Simulated digestibility by ruminants was determined by the total solubles after enzyme (TSAE) treatment of Guggolz *et al* (1971) using Onozuka cellulase SS (Yakult Biochemicals Co., Nishinomiya City, Japan) and the protease Pronase (Cal Biochem., La Jolla, Calif.). An additional digestion of each sample was performed without cellulase, but with buffer and Pronase to determine the amount of material solubilized by non-cellulase components. The difference in dry matter disappearance obtained with and without cellulase (enzyme-digested carbohydrate, EDC) is a measure of the amount of material solubilized by carbohydrate-splitting enzymes (Walker *et al* 1983).

2.4 Feeding study

Freeze-dried *P chilensis* leaves were used either before or after autoclaving (20 min at 115°C with 40% w/v water, then freeze drying) or extraction with methanol in a Soxhlet extractor. Part of the dried methanol extract (28% of leaf) was partitioned between ether and water in a separatory funnel to yield, when dried, a water-dispersible fraction (85% of dry methanol extract) and an ether-soluble fraction (15% of dry methanol extract).

Mesquite leaf meals and extracts were fed to weanling mice in two tests for up to 14 days. The composition of the diet was (w/w): protein from mesquite and casein as indicated, 8% corn oil, 5% added water, 3% cellulose, 2% complete vitamin

mixture (Friedman and Gumbmann 1984), 5% AIN mineral mixture (AIN 1977), 20% glucose, and corn starch to make 100%.

In the first feeding test, diets contained 10% w/w protein from either leaf meal or casein. To the casein diets were added amounts of leaf extracts that had been obtained from the weight of leaf meal used in the leaf-meal diets. In a second test, diets contained 10% w/w protein from casein plus either 2·5 or 5·0% w/w protein from leaf meal. The mice were weighed daily as change in body weight is a sensitive criterion for detecting toxicity in short-term rodent assays (Weil *et al* 1969).

3 RESULTS AND DISCUSSION

Analyses of mesquite leaves were compared with those of alfalfa (*Medicago sativa* L), a principal cultivated forage crop in temperate climates (Table 1). The mesquite leaves in general contained less protein and more fiber than alfalfa, but based on these analyses appear to be suitable sources of forage.

The essential amino acid content of leaves from the six species of mesquite leaves is listed in Table 2. In general the content of these amino acids is similar to that of alfalfa. Amino acid content of leaf proteins has been reported to be similar regardless of source (Byers 1971). With two exceptions (*P alba* and *P chilensis*) mesquite leaves contain amounts of lysine and the sulfur amino acids comparable to those in alfalfa. It is not known whether the lower content of sulfur amino acids in *P alba* and *P chilensis* is intrinsic or is caused by losses during processing, possibly by the high phenolic content of these two species (see below). There was a small deficiency of isoleucine and valine in the mesquite leaves. The specific amino acid content is not particularly important if the leaves are to be used as browse for ruminant animals, but is important if the leaves are to be fed to poultry or swine.

TABLE 1
Comparison of Mesquite and Alfalfa Leaf Compositions[a]

Analysis (% *dry basis*)	Prosopis *spp or cv*						*Alfalfa* (*lucerne*)
	alba	articulata	chilensis	nigra	'*Ruby*'	velutina	
N	2·59	3·08	2·93	2·94	3·25	3·23	3·66
Crude protein	16·2	19·3	18·3	18·4	20·3	20·2	22·9
Crude fiber	25·5	25·3	25·1	28·3	20·2	27·0	20·8
Fat	6·8	11·0	6·5	11·8	8·5	10·3	10·0
Ash	6·6	5·6	4·5	4·0	3·4	5·5	3·3
Neutral detergent fiber	39·0	37·2	37·5	43·3	32·6	41·8	33·9
Acid detergent fiber	35·5	28·9	28·8	31·7	27·8	33·1	28·6
Lignin ($KMnO_4$)	7·8	7·6	6·2	4·5	6·1	7·8	7·2
Cellulose	26·6	19·8	22·0	26·2	20·2	24·5	20·0
Hemicellulose[b]	3·5	8·4	8·7	11·6	4·8	8·7	5·3

[a] Mesquite and alfalfa leaves were freeze dried.
[b] Estimated = neutral detergent fiber–acid detergent fiber.

TABLE 2
Amino Acid Content of Mesquite Leaves

Amino acid (*g 16 g* N^{-1})	Prosopis *spp or cv*						*Alfalfa*[a] (*lucerne*)
	alba	articulata	chilensis	nigra	*'Ruby'*	velutina	
Arginine	5·04	5·29	4·61	4·55	4·99	4·35	5·04
Histidine	2·04	2·17	1·95	1·95	2·03	1·87	2·31
Isoleucine	3·60	3·97	3·52	3·79	4·06	3·48	5·05
Leucine	6·87	8·01	6·87	6·97	7·79	6·59	7·66
Lysine	5·62	6·07	5·67	5·82	6·00	5·49	6·11
Methionine	0·81	1·82	0·72	1·45	1·72	1·60	1·79
Methionine + cystine	2·20	3·37	1·98	2·89	3·33	3·27	3·06
Phenylalanine	4·94	5·27	4·82	5·05	5·07	4·60	5·24
Threonine	3·57	4·18	3·62	3·65	4·29	3·44	4·66
Valine	4·69	5·28	4·70	4·78	5·36	4·60	6·11

[a] Freeze-dried alfalfa (Livingston *et al* 1971).

TABLE 3
Enzymic Digestibility and Phenolic Content of Mesquite Leaves[a]

Prosopis *spp or cv*	*TSAE*[b] (%)	*EDC*[c] (%)	*Tannic acid equiv* (%)
chilensis	22·3	−4·2	21·9
alba	25·6	−2·5	17·6
nigra	39·2	3·0	8·2
velutina	43·1	6·1	10·6
articulata	45·8	11·5	12·2
'Ruby'	47·0	6·3	14·0
Alfalfa (lucerne)	58·2	24·2	3·4

[a] Dry basis.
[b] TSAE = total solubles after enzyme (cellulose + protease) treatment.
[c] EDC = enzyme-digested carbohydrate.

The enzymic digestibilities and phenolics (as tannic acid equivalents) content of the mesquite leaves are listed in Table 3. Here the mesquite leaves are quite different from alfalfa, containing 2·5 to 6·5 times as much phenolics as alfalfa. The enzymic digestibilities are negatively correlated with phenolic content. The digestibility with cellulase plus protease (TSAE) is only 22–26% in the leaves with high phenolic content, but is 39–47% in leaves containing less phenolics. Joshi *et al* (1985) have also reported low *in vitro* dry matter digestibilities of leaves of *P cinerarea* caused by high tannin contents. Negative values were obtained for digestibility by cellulase alone (EDC) of leaves from the two species with the highest phenolics content. This seems to indicate that some of the added enzyme is bound by phenolic compounds in the sample and increases the weight of the residue after digestion. This was borne out by increased nitrogen contents in the residues in these two cases.

TABLE 4
Weight Change of Mice Fed Mesquite Leaf as the Sole Source of Protein or Mesquite Leaf Extracts with Casein

Test material	*Weight gain*[a]				*Relative phenolics content of diet*
	Day 2		*Day 4*		
	N	*g*	N	*g*	
Leaf meal[b]					
dried	6	−3·5D		—[c]	1·00
autoclaved	6	−2·3C	3	−3·7D[d]	0·91
extracted	6	−2·3C	2	−4·0D[e]	0·17
Methanol extract[f]					
entire extract	6	−1·5B	6	−2·5C	0·60
water soluble fraction	6	−1·7B	6	−2·5C[g]	0·67
ether soluble fraction	6	1·5A	6	2·3B	0·004
Casein control	6	1·7A	6	3·5A	0·00
Standard error		±0·2		±0·3	

[a] Means with no letter in common are significantly different ($P<0·05$) (Duncan's multiple range test: Duncan 1955). Initial body weight 11·3±0·1 g (SE). N=number of mice per group.
[b] Diets contained 10% protein from leaf meal (N × 6·25).
[c] Found 5 dead and 1 moribund on day 3.
[d] Found 1 dead on day 3 and 2 on day 4.
[e] Found 2 dead on day 3 and 2 on day 4.
[f] Diets contained 10% protein from casein (N × 6·25).
[g] Found 1 moribund on day 4.

Mice fed diets with high proportions of mesquite leaf did not grow well, and feed consumption generally reflected weight gain. In the first feeding test (Table 4), the mice could not survive on diets in which leaf meal was the sole source of protein. The test was therefore terminated after four days. The presence of toxic components, poor palatability and possible poor nutritive value may have contributed to this poor performance. On feeding diets containing casein plus extracts of mesquite leaf, the entire extract and the water-soluble fraction were found to be equally toxic and brought about marked weight loss (Table 4). This toxicity is probably caused by the high concentration of phenolic compounds which are extracted from the leaf and concentrated in the water-soluble fraction. The diet containing the ether-soluble fraction was able to support growth almost as well as the casein control although some growth inhibition due to minor toxicity was evident on day 4.

Weight gains obtained on feeding 10% w/w protein from casein and either 5 or 2·5% w/w protein from leaf meals are shown in Table 5. The dried and autoclaved leaf meals were clearly toxic, causing severe weight loss at the 5% w/w protein level. There was some evidence, at four days with 2·5% w/w leaf protein, that autoclaving had reduced the toxicity slightly. This indicates the possible presence of a heat-labile toxin, such as a trypsin inhibitor, in the leaf. The extracted meal was considerably less toxic but still inhibited growth when fed at the 5% w/w protein level. It can be seen in Table 4 that the extracted meal is still not free of phenolic compounds.

TABLE 5
Weight Change of Mice Fed Mesquite Leaf Meal in Diets Containing 10% Protein from Casein

Test material	*Weight gain (g)*[a]			
	Day 4		*Day 14*	
	5%[b]	*2·5%*[b]	*5%*[b]	*2·5%*[b]
Leaf meal				
dried	−2·8C[c]	0·3B	—[d]	7·3B
autoclaved	−2·3C	2·8A[c]	—[d]	8·6B[c]
extracted	0·8B	3·0A	8·3B	11·3A
Casein control	3·3A		12·7A	
Standard error	±0·3		±0·5	

[a] Means within a given time with no letter in common are significantly different ($P<0·01$) (Duncan's multiple range test: Duncan 1955). Initial body weight 10·5±0·2 (SE). Number of mice per group was 6 unless otherwise noted.
[b] Diets contained 5% and 2·5% protein from leaf meal (N × 6·25) in addition to 10% protein (N × 6·25) from casein.
[c] Found 1 dead on day 4, $n=5$.
[d] Animals terminated on day 4.

4 CONCLUSIONS

Although mesquite leaves are an important source of forage for ruminant animals in some arid parts of the world, their usefulness may be limited by their relatively high content of phenolic compounds and other toxic components. Species with lower contents of phenolics were found to be more digestible by *in vitro* enzymic studies. *In vivo* studies with weanling mice confirmed the toxicity of leaf extracts with high concentrations of phenolic compounds, but did not give information about digestibility since the mice could not survive on dried mesquite leaf as a sole source of protein. Feeding studies with other and more mature animals might be more helpful.

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